Final Report on AgroEnvironmental Technology grant "Assessment of mechanized vs. manual application of predatory mites in greenhouse flower crops for thrips control"

Roy Van Driesche, Department of Entomology, University of Massachusetts, Amherst, MA 01003, 413-545-1061, vandries@fnr.umass.edu

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Dear Sirs: The following, plus attached appendices is my final report and financial accounting for the above titled project. I wish to thank the agency for its support of this work. The report follows the points listed as required components of the final report as stated in Attachment A-1 (Project Requirements) and also Attachment A (Scope of Services).

A. DETAILED DESCRIPTION OF WORK COMPLETED

The project was to conduct a trial at three MA bedding plant growers and at each site to follow densities of western flower thrips in each of three greenhouses, one of which would be a grower control (under grower management), while the other two would be treated with applications of the predatory mite *Amblyseius cucumeris*. Of the two greenhouses treated with predatory mites, one would have its applications made in the usual way by hand sprinkling from the shipping container and the other would have applications made by a mechanical device somewhat like a leaf blower. The trial was conducted at three MA growers in the spring of 2001 and final results are presented in full in the attached Floral Notes article, which follows immediately:

Floral Notes Article on Results of Trial

Use of *Amblyseius cucumeris* in greenhouse bedding plants for thrips control – is mechanical application better?

Roy Van Driesche[1], Suzanne Lyon[1], Tina Smith[2], and Paul Lopes[3]
[1]Department of Entomology, University of Massachusetts, Amherst, MA
[2]Massachusetts Extension, University of Massachusetts, Amherst, MA
[3]Massachusetts Extension, University of Massachusetts, Wareham, MA

Introduction

Western flower thrips, *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae), is the most serious pest of greenhouse bedding plants in New England. In California, releases of *Amblyseius cucumeris* (Oudemans) on chrysanthemum at 2.5 mites per leaf were unable to reduce thrips densities below 2-7 per leaf (Hessein and Parrella 1990), an unacceptable level. In Maryland, Gill (1994) found that *A. cucumeris* in a slow release

("sachet") formulation reduced pesticide applications needed for thrips control in bedding plants from 3.6 to 0.4. In an earlier Floral Notes article, we reported results of a trial run in 2000 in commercial greenhouse bedding plant crops in Massachusetts and New York that found that in this crop, *A. cucumeris* gave better control of western flower thrips when formulated as loose mites in bran (hand sprinkled onto the crop) than when formulated as live, slow release rearing units ("sachets"). In spring of 2001, we ran a further trial at three MA bedding plant growers to see if mechanical application of this mite would be more effective or more acceptable to growers than hand sprinkling. This trial was supported by the MA Department of Food and Agriculture through a grant from their AgroEnvironmental Technology Program. Here we report the results of that trial.

Materials and methods

Three growers participated in this trial. The initial design called for three treatments at each location, each in a separate greenhouse filled with bedding plants. Treatments were (1) hand sprinkling of *N. cucumeris* in a bran formulation, (2) mechanical appication with a custom-made, battery-operated, air-powdered application gun, and (3) chemically treated control under the grower's direction. However at one grower, the mechanical application treatment was lost because the grower did not place plants in the greenhouse as intended. In both treatments receiving predatory mites, we applied *N. cucumeris* at the manufacturer's recommended release rate of 106 mites/m^2 (10,000 mites per 1000 sq. ft.). We made five releases (in weeks 1, 2, 3, 5 and 7 of the 10 week crop), averaging 53 mites/m^2/wk (=5000 mites/1000 sq. ft./wk). The mite gun application device (created by Warren Sargent of AgAttac® in Visalia, California) consisted of a pvc pipe (10 cm dia) that acted as the gun barrel. Attached to the barrel was a stopcock onto which the product bottle could be fastened. Flow of bran into the barrel was by gravity, and was regulated by the degree of opening of the stopcock. Air movement down the barrel was produced by a battery-driven fan (10 cm dia). Mites were blown 1-2 meters and survivorship of mites collected in pans was 100%. Before releasing the mites, we assessed the quality of the product received from commercial suppliers by counting the number of live mites in ten 0.1 g samples from each shipment and we then adjusted the quantity of material applied to give the intended release rate.

To measure treatment effects on WFT control, we counted western flower thrips caught on yellow sticky cards, made by cutting standard sized cards (7.6 X 12.7 cm) in half. Each half card sample unit was counted on both sides and replaced weekly. There were 20 cards per greenhouse, which were held up by clips on sticks stuck into pots or flats. Cards were distributed evenly throughout the greenhouse, placing cards in most kinds of bedding plants present. Counts were made in the greenhouse with a head-mounted optical magnifier (Optivisor®), supplemented as needed with a 10X hand lens. We also measured the number of minutes needed to treat a standard area of greenhouse bedding plants (94.6 m^2, =1000 sq ft) with each of the application methods.

In a separate experiment, we assessed how far the "mite gun" would shoot the mites and what effect, if any, being shot from the gun had on the survival of mites immediately after application. This was done by applying mites with the gun in a large empty greenhouse, using pans placed at varying distances to collect mites deposited by

application. From numbers of mites in pans, we determined the average distance mites were projected and the percentage survival of mites following application.

We also asked a set of questions of all cooperating grower before and after the trial to assess their knowledge of thrips biological control and their level of interest, and how these changed as a result of the trial.

Results

Effect of gun on mites. In a large greenhouse, 21 paper targets were placed, seven at each of three distances: 2, 5 and 8 feet from the applicator. Of all mites that landed on theses target papers, 64% were on the 2 ft distant targets, 31% at 5ft, and 5% at 8 ft. All mites seen on the paper targets were alive; therefore, we conclude that mite survival after application was 100%.

Mite quality. The number of mites received per shipment averaged 73% of the number ordered.

Control of thrips by treatments. At grower 1 (Fig. 1), thrips captures in greenhouses where mites were applied by hand vs. by an air-powered gun differed only on two of 14 sample dates, but in opposite directions. At grower 2 (Fig. 2), thrips captures in the greenhouse in which mites were applied by the mite gun were consistently lower than in either the greenhouse in which mites were applied by hand sprinkling or in the grower check (chemically treated greenhouse). However, at this location, the greenhouse that was treated with the mite gun had a higher proportion of plants, such as Coleus, that didn't flower and were thus less attractive to thrips. These findings suggest that the mite gun performed as well as hand sprinkling, but not necessarily better. At grower 3, the mite sprinkle treatment suppressed thrips on all but one sample date, but the mechanical application greenhouse was lost because it was not filled with plants as intended.

Time saving with gun. Time to apply mites was reduced 47% by mechanical application (1.5 min. to treat 94.6 m^2 vs. 3.8 min. by hand).

Growers' knowledge and attitudes as expressed in the pre and post trial surveys.

Pre-Trial Surveys of Participating Growers

1. How serious of a pest is western flower thrips (WFT) in your bedding crops?
   Grower 1: WFT is very serious for us. It's our biggest pest problem, especially in late April.
   Grower 2: Not especially serious. Mostly on gerbera and New Guinea impatiens.
   Grower 3: Moderately serious, but increasingly important.
2. Do you usually apply pesticides for WFT? If so, how often per bedding plant crop?
   Grower 1: Yes, three times per season at least.
   Grower 2: Yes, we try to treat the whole range every week.
   Grower 3: Yes, we spray about 4-6 times per crop.
3. Have you ever heard of biological control of thrips with predator mites?
   All three growers had heard of this.
4. Have you ever used predatory mites for thrips?
   None of the three growers had used them before.
5. How much are you paying for chemical control of thrips in bedding plants?

None of the growers interviewed was able to give a dollar cost of their spray program.

6. How much would you be willing to spend on biological control methods for the same level of control if it meant you didn't have to spray your crop with insecticides?
   Grower 1: I would pay $500-600 for my biggest greenhouse (6,000 square feet) (=10 cents/sq. ft.).
   Grower 2: It would have to be as cost effective as spraying.
   Grower 3: I would spend up to two times as much [to use biological control].
7. Would you be willing to apply mites by hand in your crop?
   Growers 1and 3: Yes
   Grower 2: I'm not sure.
8. Would you prefer a mechanical mite applicator?
   Grower 1: Possibly, but it's not likely to be needed. My largest house is 100 x 60 sq. ft.
   Grower 2: Yes.
   Grower 3: Yes, if it's quicker.

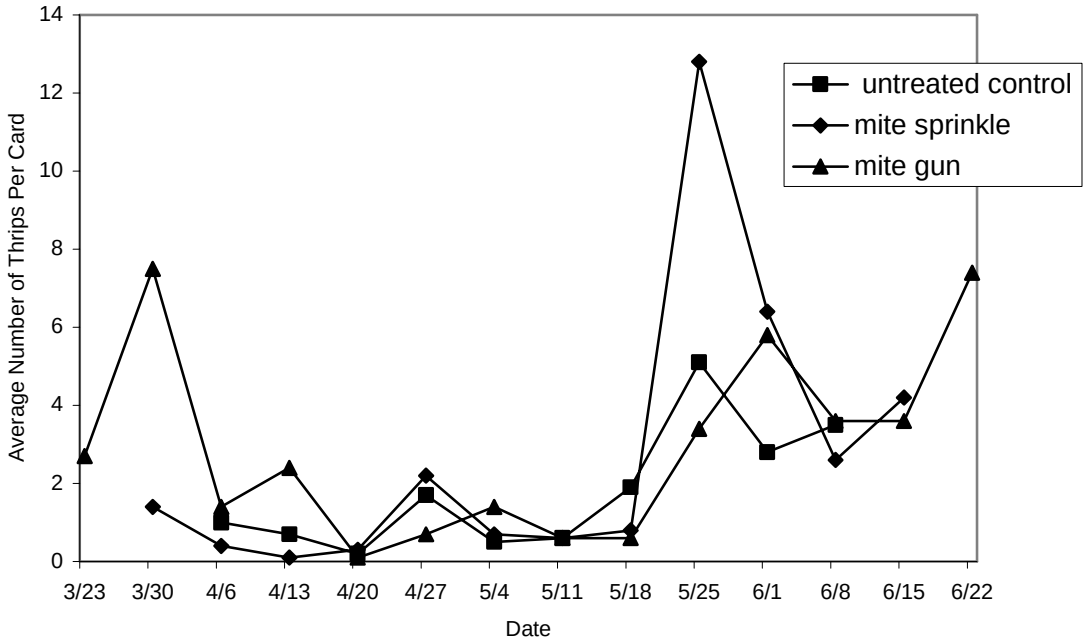
Post-Trial Surveys of Participating Growers

1. Were you satisfied with the quality of your bedding plants in the biological control greenhouses?
   Grower 1: Yes, definitely.
   Grower 2: Yes, we did see a reduction in WFT compared with other [insecticide treated] greenhouses.
   Grower 3: Yes.
2. Given the relative costs of biological control and chemical control in this trial, would you be interested in using biological mite control in your future bedding plant crops?
   Grower 1: Yes.
   Grower 2: I wouldn't mind making 5 releases [at a cost of $50 per release for 12,320 square feet], except for the cost of dealing with aphids. We need a cost-effective aphid control that's compatible with mites, either an insecticide or cost-effective biocontrol for aphids.
3. Having seen both hand application and mechanical application of mites, do you have a preference between these methods?
   Grower 1: I'd prefer mechanical because it's faster, but hand sprinkling is probably fast enough.
   Grower 2: Both worked well. We get WFT hot spots, and dealing with them might be easier with sprinkling.
4. What price would you be willing to pay for a mite application machine? Would such a machine be useful to you in other crops, of to apply other natural enemies?
   Grower 1: $150-200 maybe, but it just doesn't seem necessary. I'm not really interested. I would like to try a whirlybird spreader though.
   Grower 2: A machine is not necessary.

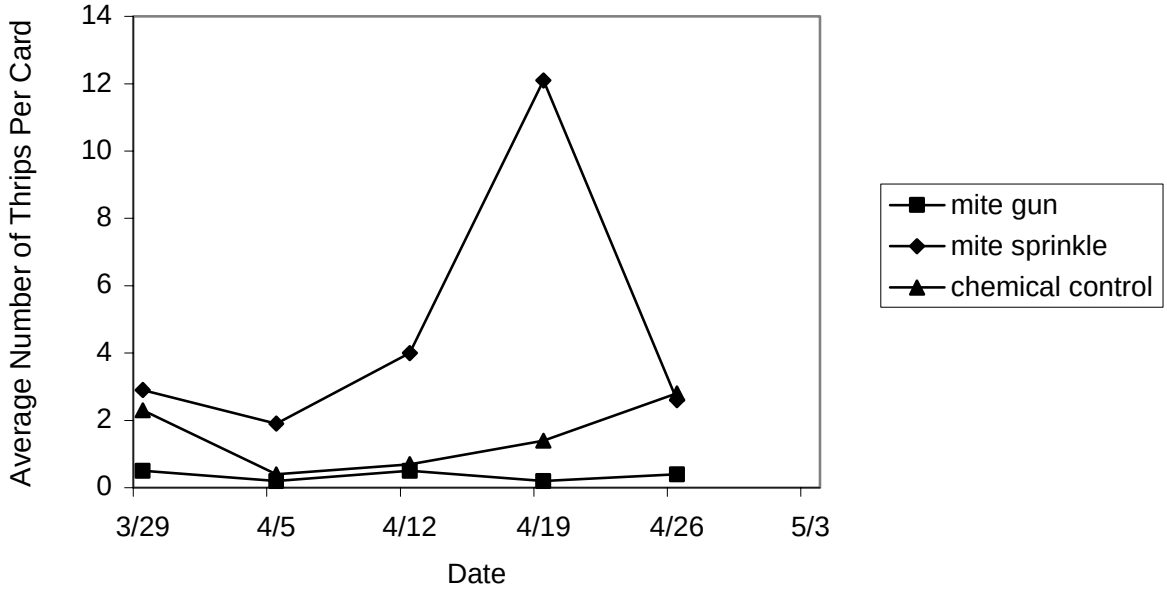
Discussion

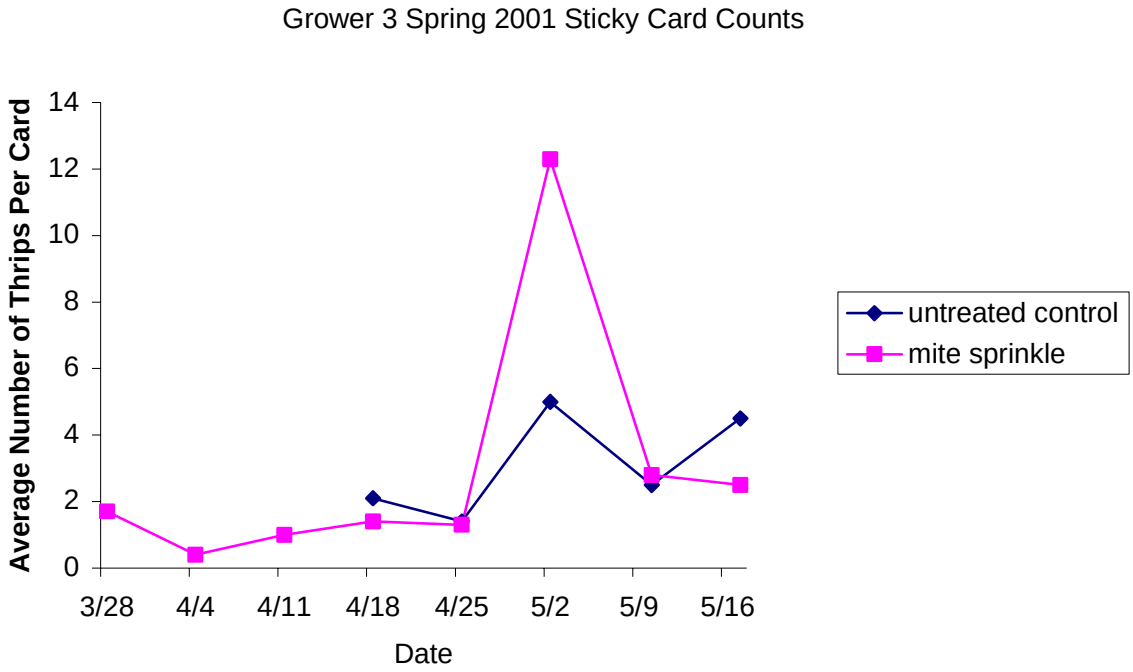
In general this trial showed that the mechanical application of mites is possible (mites reach up to 6 feet from source and have high survival after application) and is quicker. However, growers were more open to hand application than was originally assumed, so mechanical application may not be necessary. Control of thrips when mites were applied mechanically was as good as when they were applied by hand sprinkling. Grower responses in the survey suggest that they are willing to pay perhaps 10 cents per square foot for season-long biological control in bedding crops. (We plan a survey of growers to compute their real pesticide costs for thrips control in bedding plants to see what current thrips control costs are in spring bedding plants). Growers identified a need to have compatible aphid (and perhaps spider mite) controls for use in bedding plants if biological thrips control were to work for them. At the end of this trial, a meeting was held at one participating grower's site on June 20, 2001. There was a discussion of how to make thrips biological control programs work and how to manage outbreaks of other pests in the crop. Growers shared their experiences on the success of parasite releases for control of aphids, mite releases for control of spider mites, and methods to control fungus gnats. Integration of compatible pesticides with natural enemies was also discussed, as a backup approach to biological thrips control when either initial populations are too high for biological control or when natural enemy releases are not fully effective. The most likely materials for integration would be spinosad for further thrips suppression, either at the start of the crop if thrips numbers are high at the beginning due to carryover from other crops, or at mid crop to supplement biological control. If aphids are anticipated, it is recommended that early preventative releases of the parasitoid *Aphidius colemani* be made. If hot spots develop, the selective aphicide pymetrozine (Endeavor®) can be applied without disrupting the thrips biological control program.

Grower 1 Spring 2001 Sticky Card Counts



Grower 2 Spring 2001 Sticky Card Counts





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Gill, S. 1994. Thrips management and biological control. GrowerTalks 58 (6): 36-40.

Hessien, N.A. & Parrella, M.P. 1990. Predatory mites help control thrips on floriculture crops. Cal. Agric. 44: 19-21.

B. DESCRIPTION OF PROBLEMS ENCOUNTERED THAT AFFECTED THE PLAN OF WORK

Two problems were encountered in this project. The first problem was that the original design of the mite blower device did not work. It was too slow and had too little power. This problem was solved by a visit from the CA engineer who built the devive. By consulting with him, we were able to modify the gun, changing the method by which mites entered the air stream. This greatly improved the gun's performance and this second version of the gun was suitable for use in the project.

The second problem that arose in the project was that one grower, despite repeated assurances to us that he was about to fill one of the three greenhouses in the trial at his site, never did so. This resulted in the loss of that grower from the trial.

C. STATEMENT OF WHETHER THE PROJECT'S GOALS AND OBJECTIVES WERE ACHIEVED

The goal of this trial was to determine if mechanical application of predatory mites in bedding plants would result in effective mite control, be faster and cause more growers to be willing to use predatory mites in place of chemicals for thrips control. Our

results suggest that the mite gun did result in control that was as good as, but not better than, that from hand sprinkling. Also, our results showed that mechanical application was faster (taking only about half as much time as hand application). A surprise to us, however, was that growers did not place a big premium on this time reduction. When they actually saw the process of hand application, they felt it was also a very acceptable means of applying mites. The end result has been that more growers are interested in using biological control for thrips but that hand application, not mechanical application, is what most growers will likely choose to use.

D. LIKELIHOOD OF IMPLEMENTATION OF PROJECT RESULTS IN MA FOOD AND AGRICULTURE INDUSTRY

The likelihood that more MA bedding plant growers will eventually adopt biological thrips control is high. This was shown by grower response at a January 22, 2002 meeting in which Suzanne Lyon presented the results of this and related projects in our laboratory on biological thrips control and solicited participation by growers interested in adopting biological methods (for thrips and other pests) in their bedding plant crops. Eight growers responded to this request and three of these growers will be enrolled in the spring 2002 trial on the combination of predatory mites and a selective insecticide (spinosad). It is likely, however, that if growers do want to use mechanical application (which might be the case for the very largest growers), that they will be able to meet their needs by use of a very simple device, a hand operated seed spreader, which can throw granular material such as is used to formulate *A. cucumeris* for a similar distance to the device tested here and is cheaper.

E. ECONOMIC IMPACT OF PROJECT

The economic impact of this project in the narrow sense (adoption of mechanical application) is slight, but in the broader sense (adoption of thrips biological control), it is greater. Grower interest in use of predator mites for thrips control is gradually increasing. Each trial gets the attention of a few more growers. Our most recent effort to get new volunteer growers for further work (spring of 2002) was the first to produce more volunteers than we were looking for. So interest seems to be growing.

F. DESCRIPTION OF ENVIRONMENTAL CONCERNS ADDRESSED AND EFFECTS OF THE PROJECT

The environmental concern being addressed is the public's desire to reduce pesticide use. Since greenhouse acreage is low compared to other crops, the environmental impact of reducing pesticides in this crop is not great at the landscape level. However, since relatively intensive pesticide use occurs on this small acreage, the people working there are exposed to higher pesticide residues than outdoor farm workers. Therefore, reduction of this high level of pesticide use would at least have a benefit for the greenhouse operators and their workers. .

G. NUMBER OF ACRES POTENTIALLY AFFECTED BY PROJECT

The green industry (greenhouse plus nursery) is the largest agricultural sector in Massachusetts, in the sense of sales. For greenhouses alone, in 2000 there were 411 commercial flower and bedding plant growers with sales exceeding $10,000, who produced crops with a wholesale value of $77.5 million (New England Agricultural Statistics Service, 2001). Other operators selling less than $10,000 worth of product are not included in these numbers. Flower crops are produced in 217 acres of greenhouses (up 41% since 1993) and 407 acres of associated open fields (New England Agricultural Statistics Service, 2001). Most of these operations have thrips problems and could benefit from this project.

H. OTHER IMPACTS OF PROJECT

There are no other important impacts of this project.

I. FINAL BUDGET OF ACTUAL EXPENSES AND COSTS SHOWING GRANT AND MATCHING MONIES USED IN THE PROJECT

The total budget for the project was $14,000, of which $7000 was supplied by DFA, $1750 by MFGA, and $5200 by UMASS. The following table provides an accounting of the money allocated by each contributor to particular cost, with linkage to purchase orders or other statements verifying that expenditures were made for the budgeted items at the budgeted dollar amounts.

AMOUNT	BUDGET CATEGORY	DOCUMENTATION OF EXPENDITURE
DFA funds		
$3500	Wages for technician	Item 1 (appointment document)
$1800	Mites and other supplies	Item 2 (purchase order or pro card statement or billing)
$800	Charges for publication	Item 3 (purchase order or pro card statement or billing)
$200	Photocopy charges	Item 4 (internal recharge form)
$700	Travel	Item 5 (Un Taek Lim's travel to San Diego for ESA meeting, present expense claim document)
MFGA funds		
$1750	Supplies	Item 6 (purchase order or pro card statement or billing)

UMASS funds		
$3500	Salary of PI (Van Driesche)	Item 7 (statement of PI's wage and number of hours worked on project)
$1088	Salary of technician (from Hatch funds)	Item 8 (statement of technician's wage and number of hours worked on project)
$662	Purchase of mite gun on Hatch	Item 9 (purchase order)
Project total = $14,000		

Response to Points in Scope of Services, Attachment A

1 abc. Run the trial. The trial and preliminary assessment of the mite gun's performance as called for in the proposal were run in spring of 2001. Results are reported earlier in this document (see Floral Notes article, pp. 1-6).

1.d. Hold one grower meeting. We held a grower meeting on June 20, 2001 in Stow, MA to discuss the results with growers (see advertisement for documentation of event). Several growers attended and a round table discussion was held on thrips biological control, following some formal presentations and demonstration of how to use the mite gun.

2a. Preliminary testing of mite gun. Measurements of the distance mites were thrown by the mite gun and their survival following the application were made and are reported in the Floral Notes article at the beginning of this document.

3abc. Publication of results. To reach the scientific community, results of the project have been accepted for publication in the proceedings of the May 6-9, 2002 international greenhouse meeting (IOBC NRS, WPRS) to be held in Victoria, BC, Canada (copy attached as Appendix I). To reach growers, results of this project have been submitted for publication in an upcoming issue of Floral Notes in spring of 2002 (see copy at front of this document, pp. 1-6).

3d. Oral presentation of results. The results of this project will be discussed at the upcoming meeting international greenhouse meeting (IOBC NRS, WPRS) to be held in Victoria, BC, Canada in May of 2002.

Other requirements.

1. Photos (24) of the project are submitted with this report

2. Financial accounting. See the table presented earlier in this report for an accounting of the finances of the project. Supporting items mentioned in table are attached and labeled as indicated in the table (Appendix II).

Appendix I.

Greenhouse trials in Massachusetts and New York with *Amblyseius cucumeris*: effects of formulation and mechanical application

Roy Van Driesche[1], Suzanne Lyon[1], John Sanderson[2], Tina Smith[3], Paul Lopes[3], Susan MacAvery[4], T. Rusinek[4], and Gary Couch[4]
[1]*Department of Entomology, University of Massachusetts, Amherst, MA, 01003, USA*
[2]*Department of Entomology, Cornell University, Ithaca, NY, 14853, USA*
[3]*Massachusetts Extension, University of Massachusetts, Amherst, MA, 01003, USA*
[4]*Cornell Cooperative Extension of Orange and Ultster Counties, NY, USA*

Abstract: Trials in spring bedding plant crops in 2000 and 2001 in Massachusetts and New York commercial greenhouses measured the ability of *Neoseiulus* (*Amblyseius*) *cucumeris* to control western flower thrips, *Frankliniella occidentalis*. In 2000, the effect of formulation (mites in bran vs. sachets) was examined at three businesses. At all three sites, we found that sticky card catches of adult thrips were lower in greenhouses receiving mites formulated in bran vs. sachets. In 2001, we compared western flower thrips densities in greenhouses in which *N. cucumeris* releases were made either via hand application (sprinkle) of mites formulated in bran or mechanical application of the same material with a battery powered air blower ("mite gun"). Results suggested that the two application methods did not differ in their ability to suppress thrips populations.

Key words: western flower thrips, predacious mites, formulation method, application method, *Neoseiulus* (*Amblyseius*) *cucumeris, Frankliniella occidentalis,* biological control, bedding plants

Introduction

Western flower thrips, *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae), is the most serious pest of greenhouse bedding plants in New England. In California, releases of *Neoseiulus* (*A.*) *cucumeris* (Oudemans) on chrysanthemum at 2.5 mites per leaf were unable to reduce thrips densities below 2-7 per leaf (Hessein and Parrella 1990), an unacceptable level. In Maryland, Gill (1994) found that *N. cucumeris* in a slow release formulation reduced pesticide applications needed for thrips control in bedding plants from 3.6 to 0.4. We report results of trials in commercial greenhouse bedding plant crops in Massachusetts and New York that examined the ability of *N.* (*A.*) *cucumeris* to control western flower thrips. A 2000 trial compared two formulations (mites formulated loose in bran ["bulk release"] vs. paper sachets ["slow release"]) and the 2001 trial examined mechanical application versus hand sprinkling of mites in bran.

Material and methods

2000 trial on formulation

In this trial there were three treatments: sprinkle application of mites formulated loose in bran (bulk release), sachets, and the chemically-treated grower check. The trial was run at three growers, two in Massachusetts and one in New York. At both Massachusetts sites there were three greenhouses, one for each treatment. Greenhouses were filled with flats

of diverse bedding plant species. In New York, there were only two greenhouses, one a bulk release and one a sachet greenhouse, both of which contained only potted dahlias.

In the Massachusetts greenhouses receiving bulk releases of N. cucumeris, we followed the manufacturer's recommended release rate of 106 mites/m^2 (10,000 mites per 1000 sq. ft.) and we made five releases (in weeks 1, 2, 3, 5 and 7 of the 10 week crop), averaging of 53 mites/m^2/wk (=5000 mites/1000 sq. ft./wk). In the New York greenhouses, the release rate was twice as high (212/m^2 or 20,000 mites per 1000 sq. ft) and releases were made in weeks 1, 3, 5, 7, 9, 11, 13 of a 14 week crop, giving an average of 106 mites/m^2 /wk (10,000 mites/1000 sq. ft./wk). For mites applied using the sachet formulation, in Massachusetts we applied 1 sachet per 2.5 m^2 (=37 sachets per 1000 sq. ft, or 1 per 27 sq. ft), as recommended by product producer for preventative control. Sachets are reported by manufacturers to last 8 weeks, but replacement is recommended after 6 weeks for bedding plants. In Massachusetts, two deployments of sachets were made, in weeks 1 and 6. In New York, sachets were deployed in week 1 at a rate of one per 2.7 m^2 (40 sachets per 1000 sq. ft.). Subsequently, one third of the sachets were replaced in weeks 3, 5 and 7, and again in weeks 9, 11, and 13. In both the sachet and bulk release greenhouses, we allocated 5% of the total material to be released for placement into hanging baskets. In the sachet greenhouses, this was achieved by tearing open some sachets and placing the contents in the baskets. In both states in all but the chemical checks, one release was made of Hypoaspis miles Berlese at a rate of 106 mites /m^2 (10,000 per 1000 sq. ft) onto the media (or in the pots) at the beginning of the crop.

In Massachusetts, we assessed the quality of mites formulated in loose bran by counting live mites per 0.25 g in 10 samples from each shipment. To assess quality for sachets, we retrieved 3 sachets from each grower weekly and placed them flat on a 15 x 25 cm sticky card on a greenhouse bench. After one week, cards were collected, sachets removed and mites counted. Mite counts from aged sachets were compared to that for new sachets just received from the supplier and held under the same conditions.

To measure treatment effects on WFT control, we counted western flower thrips caught on yellow sticky cards, made by cutting standard sized cards (7.6 X 12.7 cm) in half. Each half card sample unit was counted on both sides and replaced weekly. There were 20 cards per greenhouse, which were held up by clips on sticks stuck into pots or flats. Cards were distributed evenly throughout the greenhouse, placing cards in most kinds of bedding plants present. Counts were made in the greenhouse with a head-mounted optical magnifier (Optivisor®), supplemented as needed with a 10X hand lens.

2001 trial on application technique

In this trial, there were two treatments: (1) application via hand sprinkling of *N. cucumeris* in a bran formulation and (2) mechanical appication of the same with a custom-made, battery-operated, air-powdered application gun. Application rates and patterns were the same as in the 2000 Massachuesetts bulk release greenhouses. The mite gun application device (created by Warren Sargent of AgAttac® in Visalia California) consisted of a pvc pipe (10 cm dia) that acted as the gun barrel. Attached to the barrel was a stopcock onto which the product bottle could be fastened. Flow of bran into the barrel was by gravity, and was regulated by the degree of opening of the stopcock. Air movement down the barrel was produced by a battery-driven fan (10 cm dia). Mites were blown 1-2 meters and survivorship of mites collected in pans was 100%.

We assessed the quality of the product received from commercial suppliers before release by counting the number of live mites in ten 0.1 g samples from each shipment. We evaluated the efficacy of each method of application by means of sticky trap catches of adult thrips in each greenhouse as was done in the Massachusetts greenhouses in the 2000 trial, described earlier. We also measured the number of minutes needed to treat a standard area of greenhouse bedding plants (94.6 m^2, =1000 sq ft) with each of the application methods.

Results and discussion

Formulation trial (2000)

At grower 1 (Fig. 1a) there was little difference in thrips catch among treatments, but the chemical control greenhouse consistently had the highest catches, followed by the sachet greenhouse. The greenhouse in which mites formulated loose in bran were applied had the lowest thrips catches on 5 of 8 sample dates (with numbers on the other three dates being the same as in the sachet greenhouse). At grower 2 (Fig. 1b), the grower did not make any pesticide applications in the grower check greenhouse and numbers of thrips reached 48 per card. The greenhouse receiving mites formulated loose in bran had the lowest counts on 3 of 6 sample dates and on the other three dates was not different from trap catch numbers in the sachet greenhouse. (Parts of both sachet and bulk greenhouses were treated with acephate on 27 April for aphids). At grower 3 (Fig. 1c**),** trap captures of thrips were lower in the greenhouse receiving mites formulated loose in bran than sachets. We conclude that the *N. cucumeris* formulated loose in bran is more effective than sachets in bedding plant crops.

Mechanical vs hand application trial (2001)

At grower 1 (Fig. 2a), thrips captures in greenhouses where mites were applied by hand vs. by an air-powered gun differed only on two of 14 sample dates, but in opposite directions. At grower 2 (Fig. 2b), thrips captures in greenhouses in which mites were applied by the mite gun were consistently lower than in either the greenhouse in which mites were applied by hand sprinkling or in the grower check (chemically treated) greenhouse. However, at this location, the greenhouse that was treated with the mite gun had a higher proportion of plants, such as Coleus, that didn't flower and were thus less attractive to thrips. These findings suggest that the mite gun performed as well as hand sprinkling, but not necessarily better. Time to apply mites was reduced 47% by mechanical application (1.5 min. to treat 94.6 m^2 vs. 3.8 min. by hand).

Mite quality

For mites formulated loose in bran, in 2000 the number received per shipment ranged from 59 to 187% of the number ordered and averaged 118%. In 2001, the average number received was 73% of the number ordered. For mites in sachets, in 2000 we found that numbers of mites emerging per week remained at or above levels from fresh sachets for 3 weeks and then decline to 34% of the emerged from a fresh sachet by week 7 (Fig. 3).

Acknowledgements

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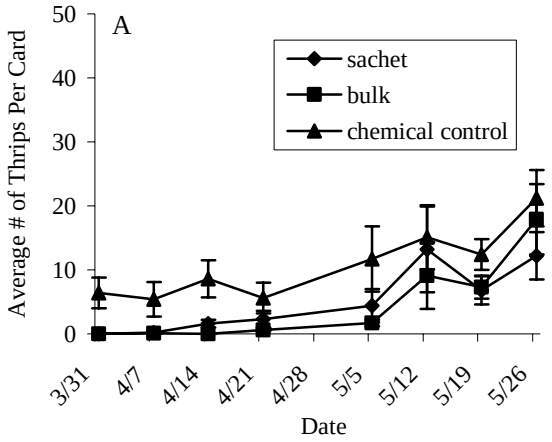
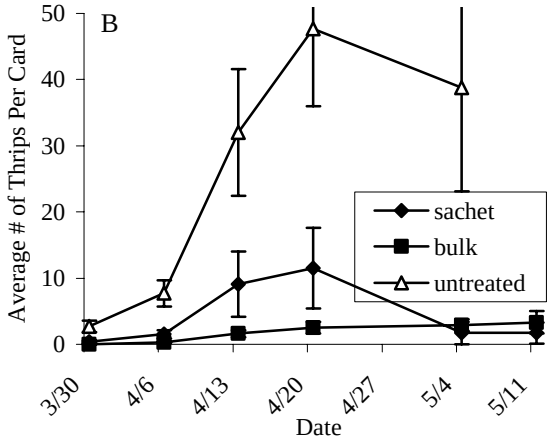




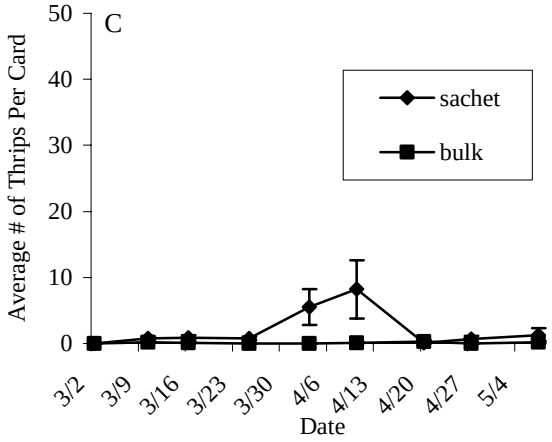
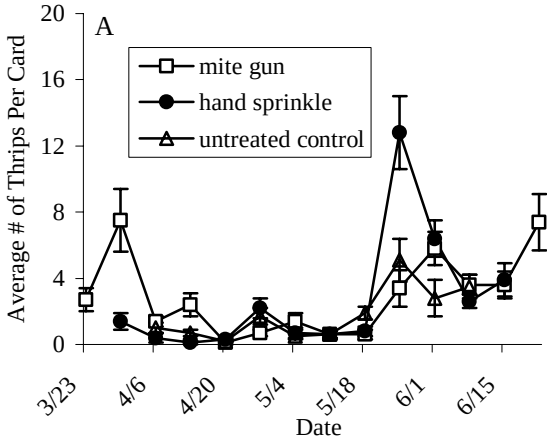


Figure 1: Count of western flower thrips on sticky cards for two *A. cucumeris* formulations at three sites in MA (A,B) or NY (C) in 2000.



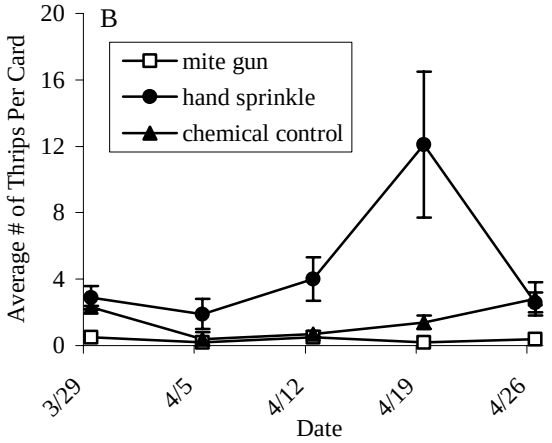


Figure 2: Counts of western flower thrips on sticky cards for mechanical vs. hand application of *A. cucumeris* at two sites in MA in 2001.

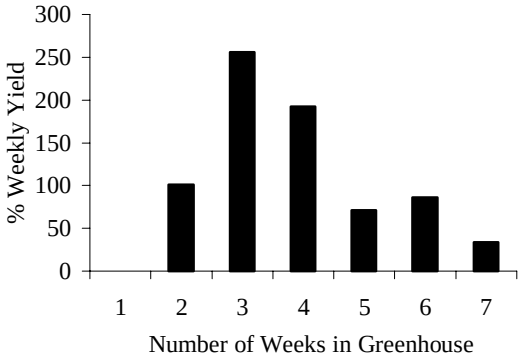


Figure 3: Yield of *A. cucumeris* aged sachets per week relative to the weekly yield of a fresh sachet.